Improved Clouds and Precipitation Products for NWP

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Motivation

- Improve understanding of microwave radiometer observations of snowfall over land, particularly for high frequency channels (>= 85 GHz) that are sensitive to ice scattering. These sensors include AMSU-B/MHS and SSMIS and GMI on the upcoming GPM mission.
- Develop snow hydrometeor training database for radiative transfer modeling
- Improve radiative transfer modeling error characterizations for falling snow over land

What are the challenges?

- Lack of trustworthy falling snow in situ truth coincident with microwave observations
  - 3-D snow size, density and habit distributions
- Ice particle scattering
- Land surface emissivity

Land Challenges
Surface Emissivity

Differences between land and ocean surface?

ocean

• Emissivity ~ 0.5
• Ocean emissivity can be well described by wind speed/SST/salinity

land

• Emissivity ~ 1.
• Highly variable in space and time
• Difficult to describe land emissivity variations with surface types, roughness and soil moisture

Complex Snow Emissivity

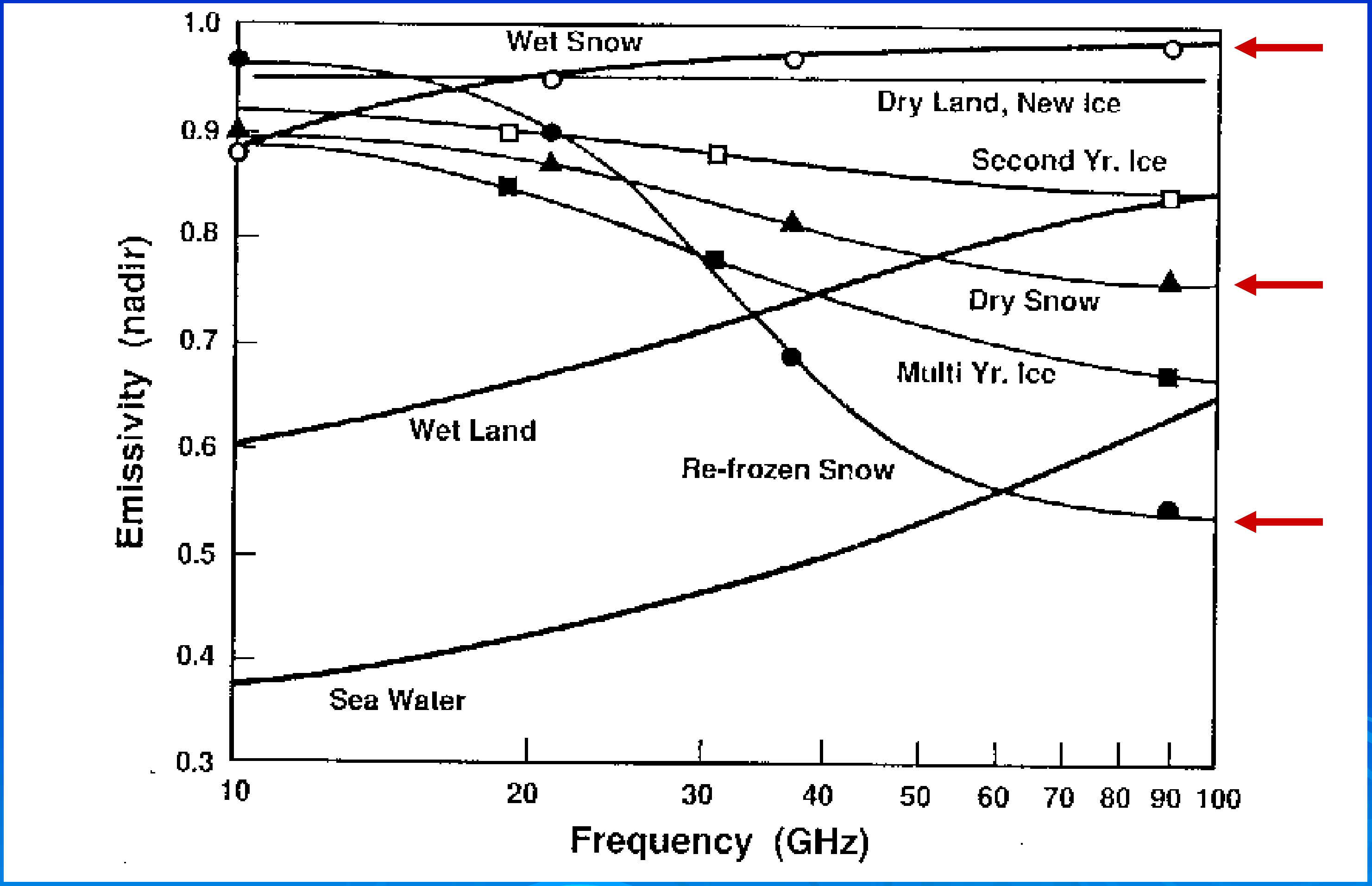


Figure from Norm Grody

Cold Season land Emissivity Example

CNRM Microwave Monthly Emissivity Atlas (0.25 X 0.25 grids),

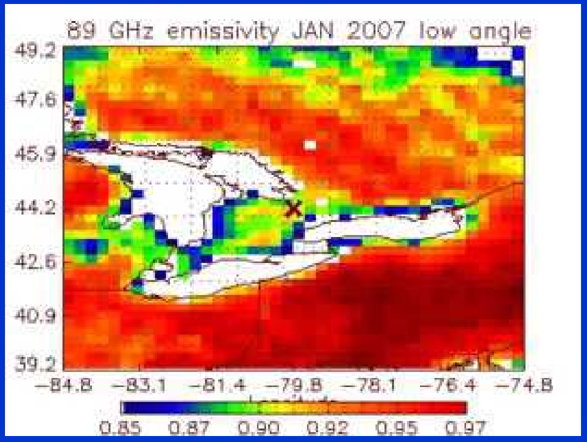
January 2007 AMSU-A 89 GHz

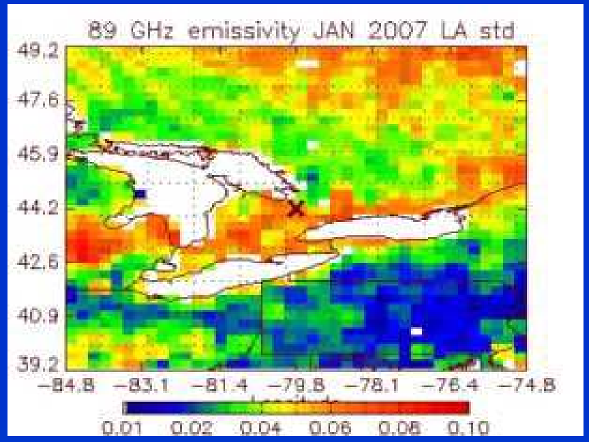
highly variable in space, time and satellite incidence angle

Monthly mean value

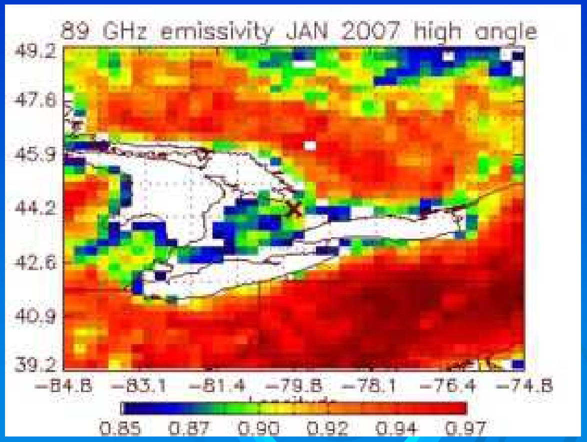
Standard deviation

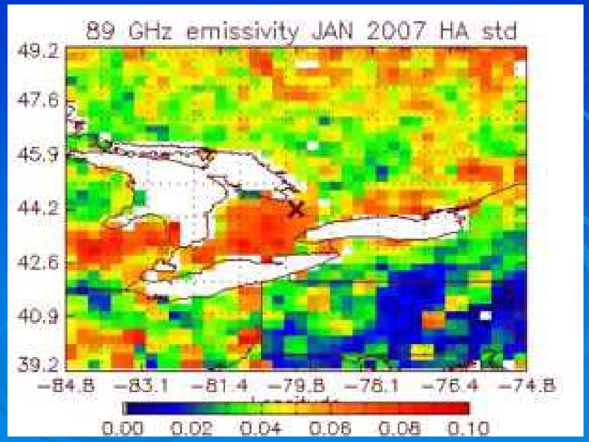
Low incidence angle
< = 40°



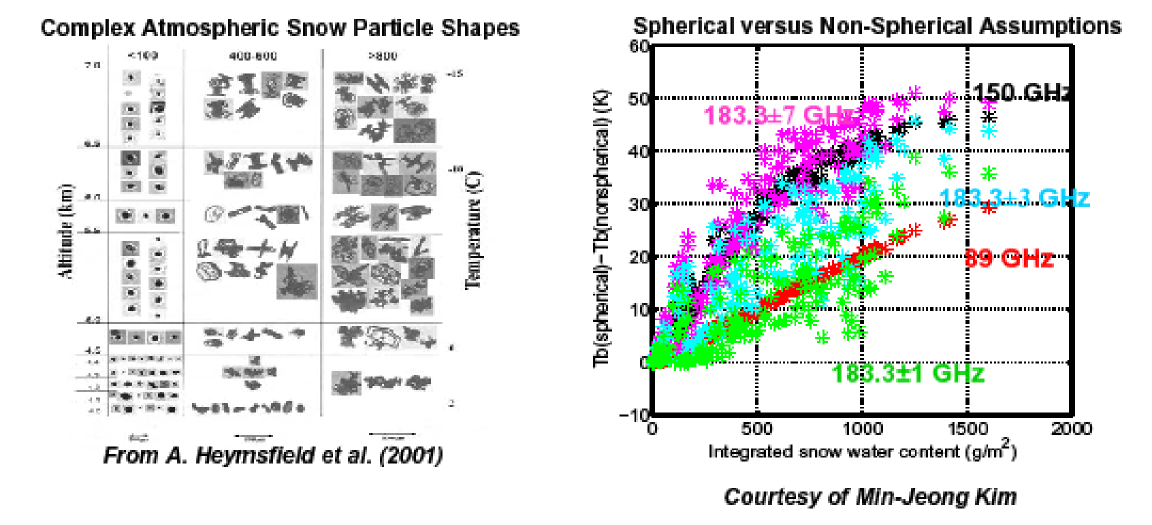


High incidence angle
> 40°





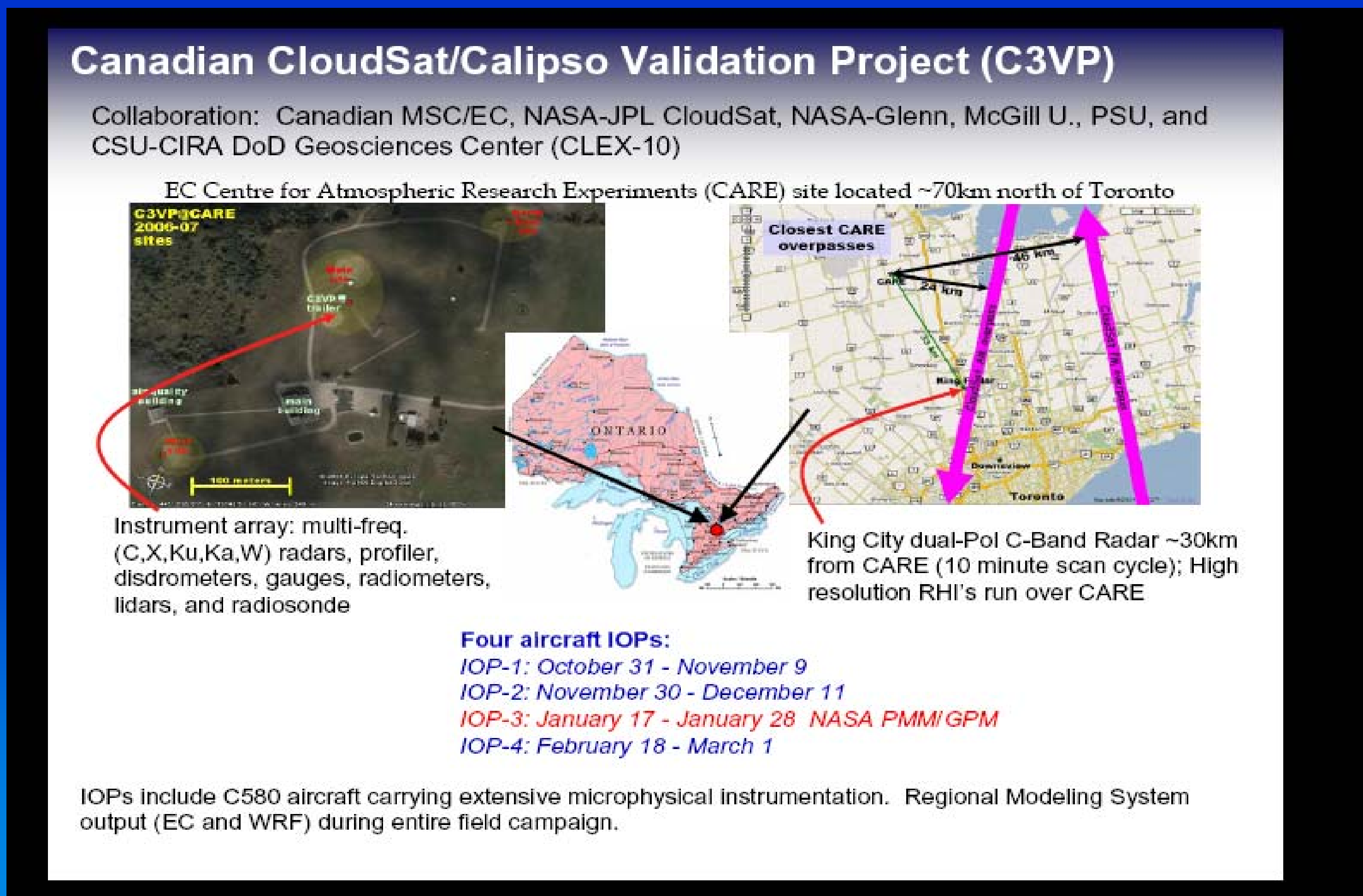
Land Challenges
Snow Particle Models



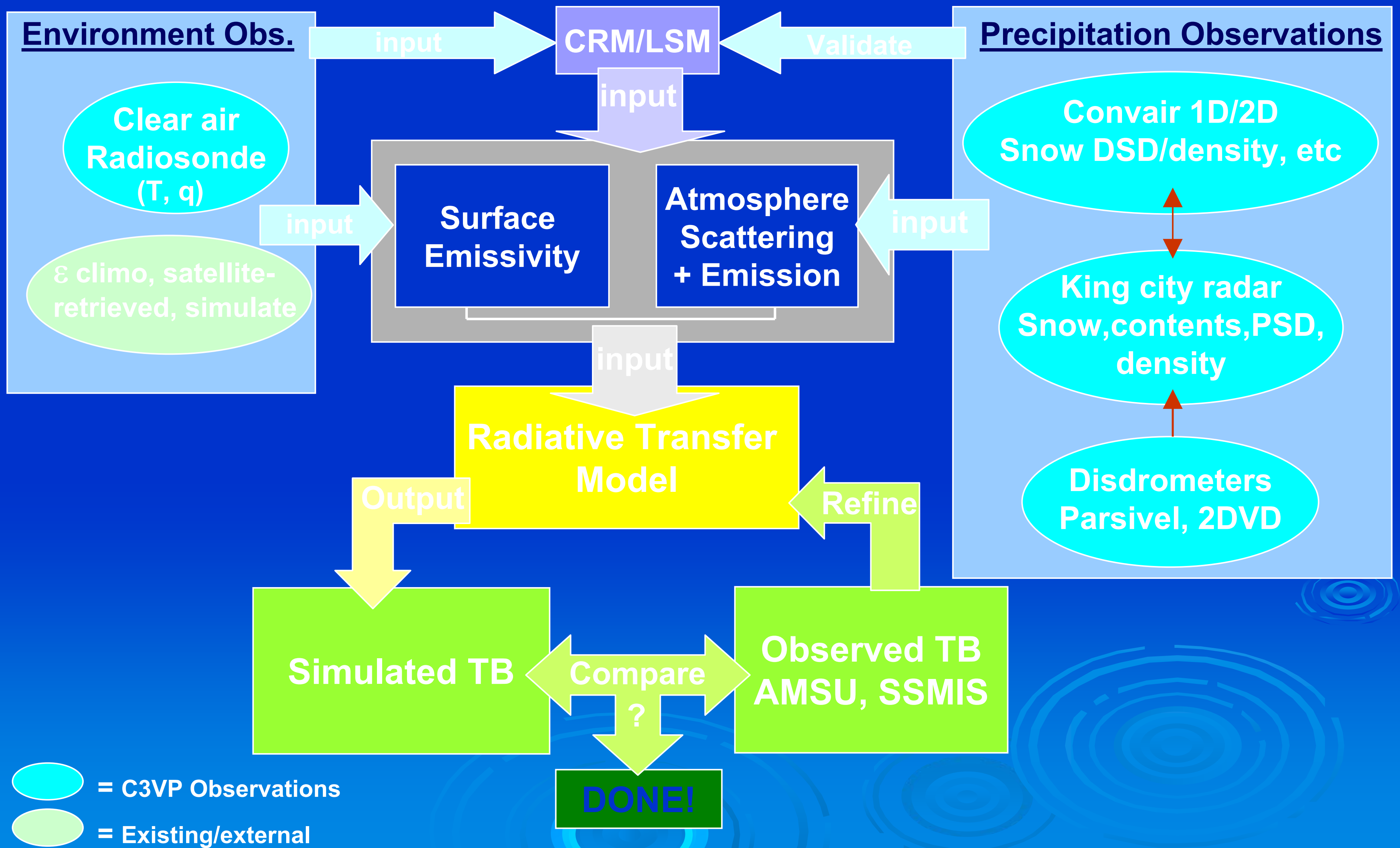
- Sphere and simple dielectric mixing formulations are often used to model snow. Snow particles are non-spherical and complex in shapes in nature.
- Methods such as DDA (discrete dipole approximation) are capable to compute radiative properties for idealized snow particle shapes. Large discrepancies may result due to shape assumptions.

Approach

- Leverage satellite ground campaigns such as C3VP



Multi-frequency forward modeling to simulate brightness temperatures given C3VP measured atmospheric state, observed and/or CRM-simulated hydrometeor profiles



C3VP Instruments

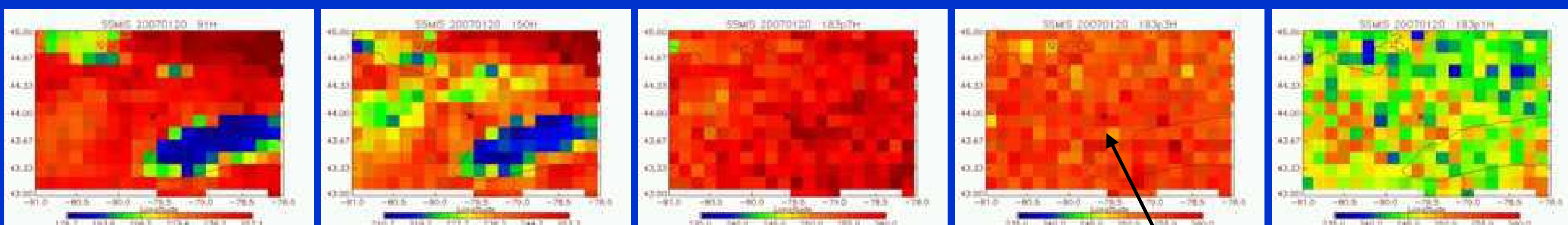
Source: Walt Petersen

Radiometer Snow Observations

January 20, 2007, lake effect snow bands

DMSP F-16 SSMIS overpass at 00:22 UTC

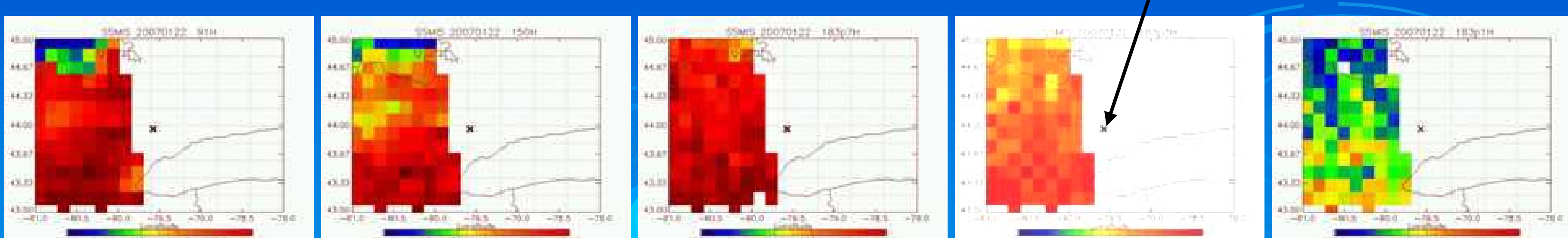
91 GHz | **150 GHz** | **183±7 GHz** | **183±3 GHz** | **183±1 GHz**



January 22, 2007, synoptic snow system

DMSP F-16 SSMIS overpass at 01:38 UTC

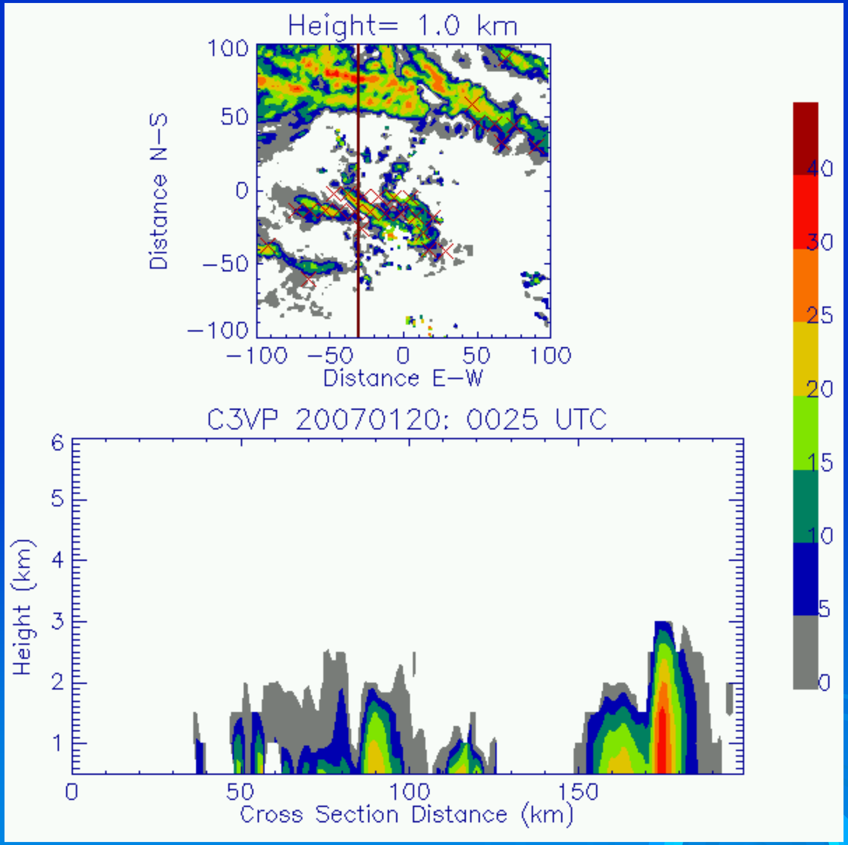
King city radar



Snow viewed by radar volume scan

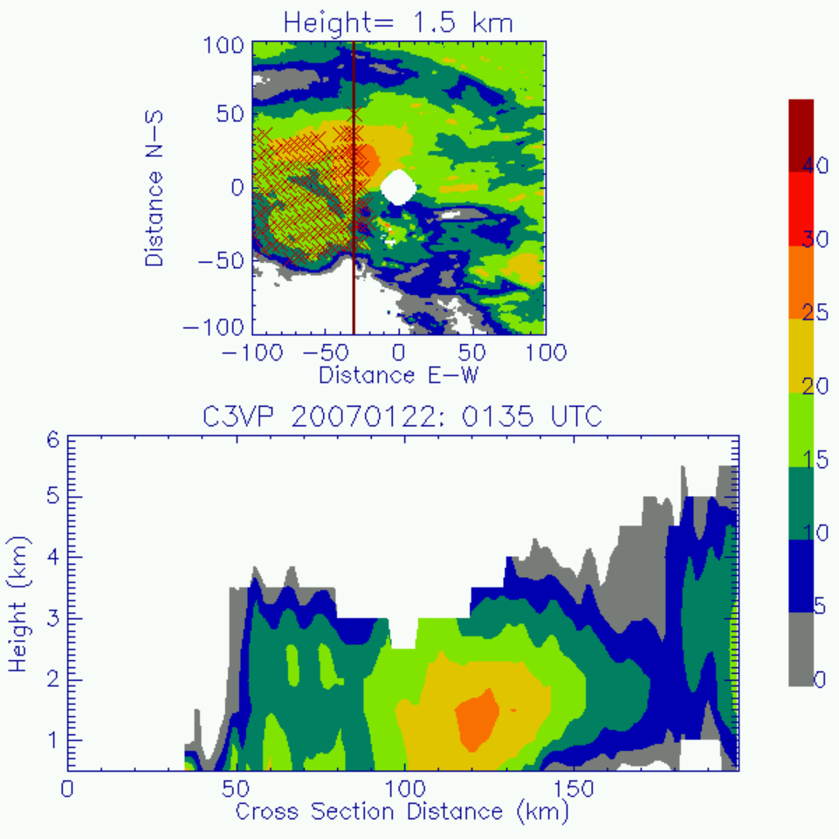
January 20, 2007

Lake effect snow bands



January 22, 2007

Synoptic snow system



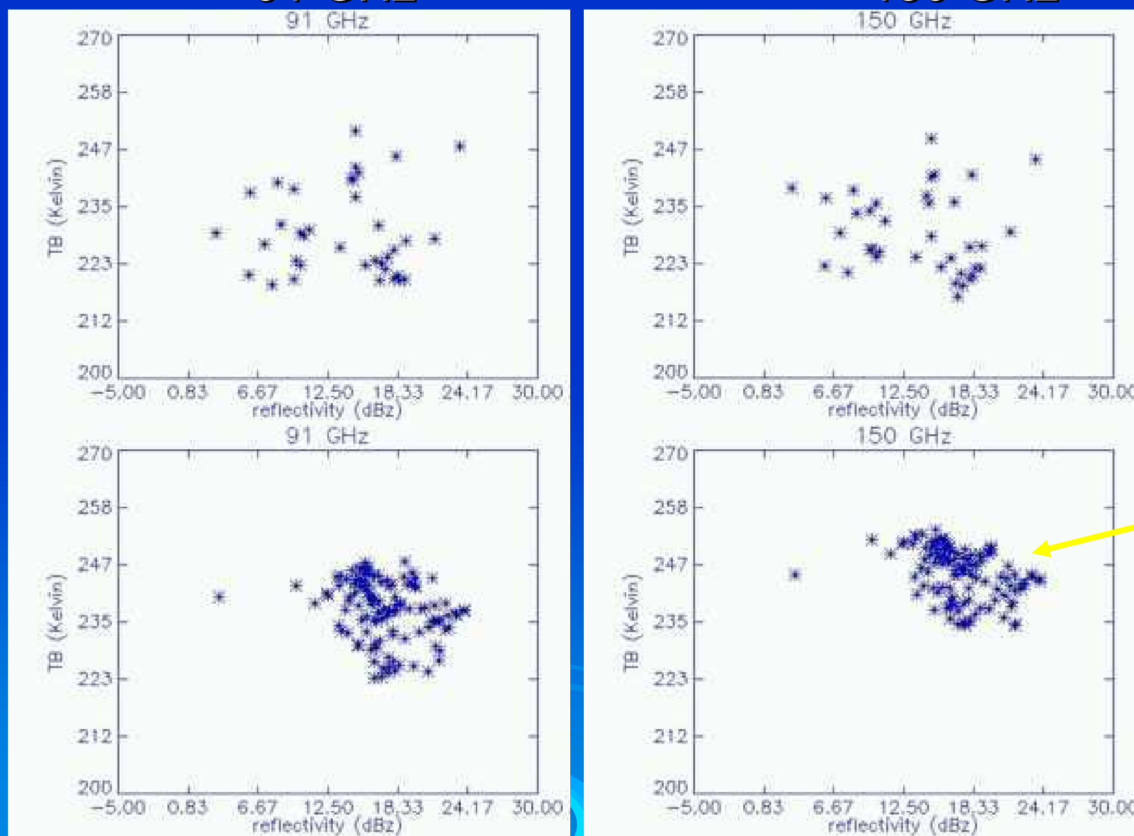
radiometer and radar correlation
window channels (91 and 150 GHz)

- Multiple radar reflectivities of 1km horizontal resolution are distance-weighted averaged to SSMIS 13 km X15 km footprint

91 GHz | 150 GHz

January 20, 2007
Lake effect snow

January 22, 2007
Synoptic snow



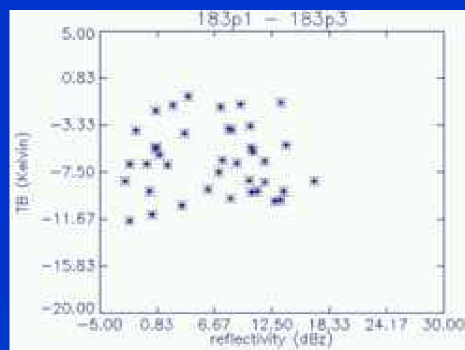
20 K sensitivity

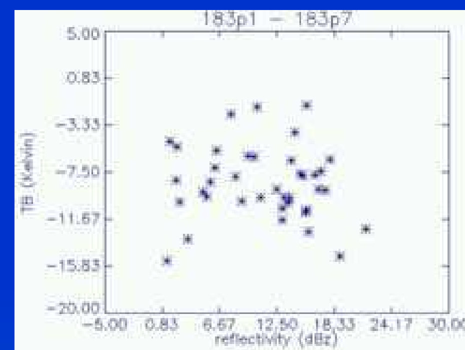
radiometer and radar correlation water vapor channels (183 GHz)

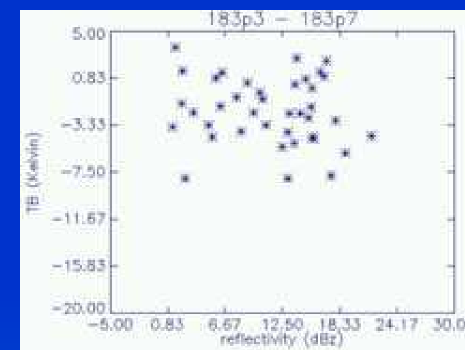
- Channel differencing to emphasize on hydrometeor effects and subtract out temperature and humidity influence

183±1 - 183±3 | 183±1 -183±7 | 183±3 - 183±7

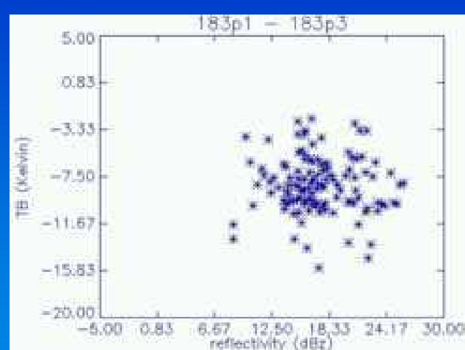
January 20,2007

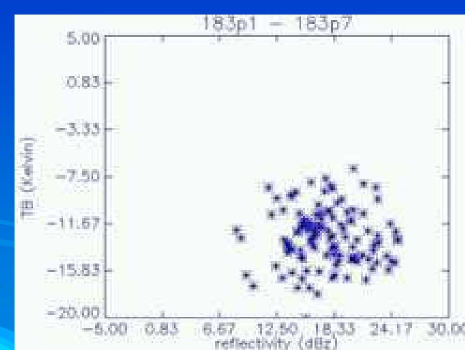


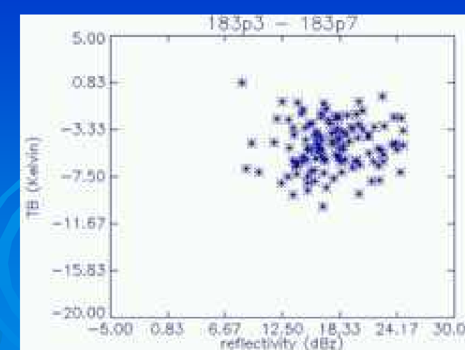




January 22, 2007





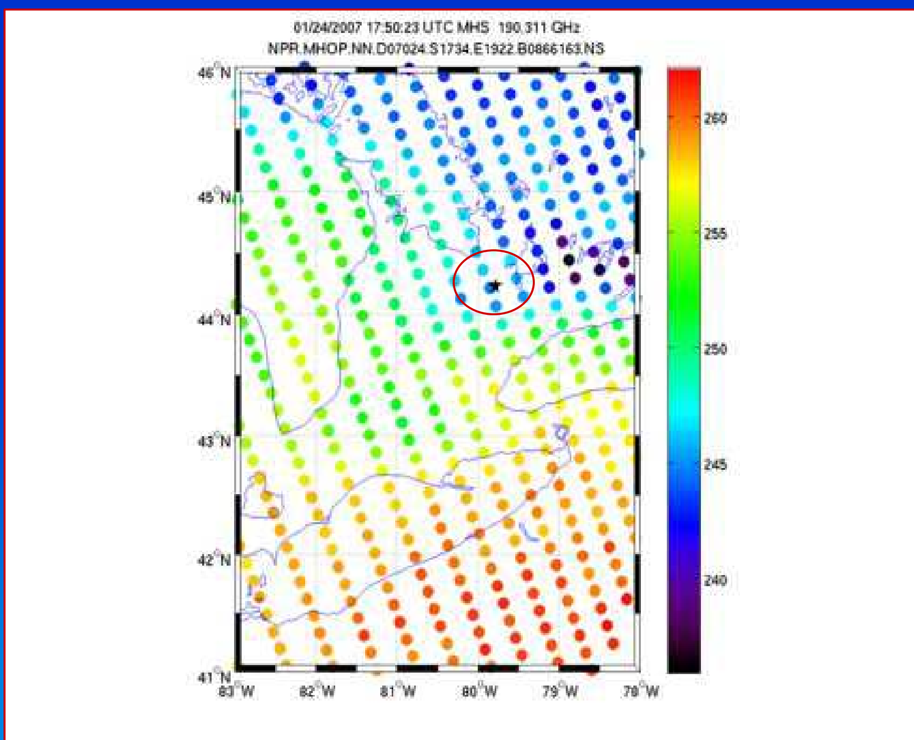


Emissivity Estimate Example (1)

- Simulate AMSU-B clear air radiances (with incidence angles) using radiosonde data and surface emissivity atlas at 89 GHz
- Compare 50km-averaged simulated and observed microwave radiances, then adjust the emissivity spectra so that the radiance differences are within errors (radiometric + (sampling + radiosonde + modeling) ~=0.5) errors
- Possible source of errors
  - AMSU–B radiometric noises and calibration errors
  - sampling errors due to atmospheric and surface imhomogeneity
  - radiosonde measurement error in humidity and temperature
  - RT model error
  - Emissivity error

Emissivity Estimate Example (2)

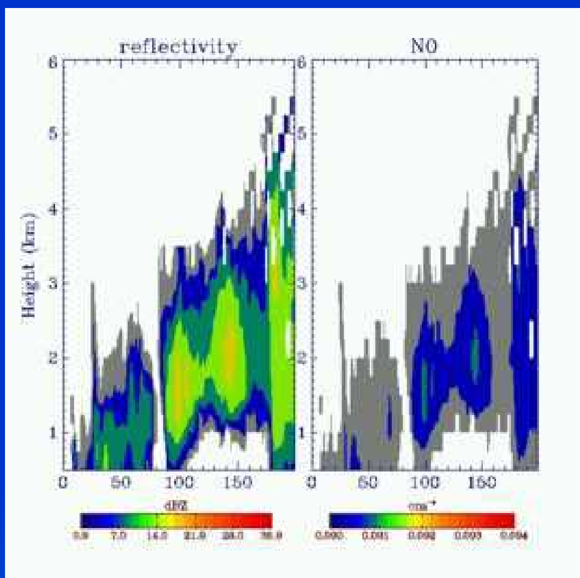
- NOAA 18 MHS January 24, 2007 pixles within 50 km of CARE Radiosonde site (44.14, -79.47)



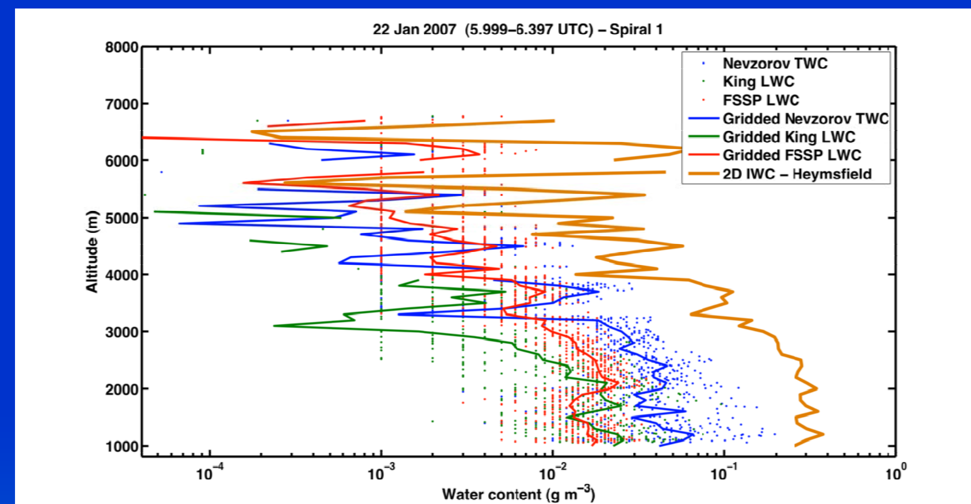
Frequency (GHz)	NEΔT	Mean (obs – sim)	Emissivity atlas	Emissivity fit
89.0	0.37	-1.38	0.878	0.870
157.0	0.84	-13.79	0.878	0.818
183.31± 1	1.06	-3.61	0.878	0.834
183.31± 3	0.7	0.11	0.878	0.834
183.31± 7	0.6	-2.33	0.878	0.834

Atmosphere inputs for RT Modeling January 22, 2007 case

Size distribution derived from radar/disdrometer



Aircraft microphysics data



- Particle size distribution and bulk microphysics measurement
  - 3-D PSD is derived using disdrometer (compute volume medium size) and C-band radar reflectivity→ will compute vertical bulk microphysics such as liquid water content and ice water content, and compare with aircraft microphysics measurements to verify PSD and density assumptions

Summary and Future Plans

Summary

- Satellite Passive microwave shows sensitivity to snowfalls, snowfall detection is achievable
- Field data inputs for radiative transfer modeling are works in progress, including radar derived snow DSD, aircraft snow microphysics, and surface emissivity estimates.

Future Plans

- Continue field data analyses to develop realistic 3-dimensional frozen hydrometeor profile database
- Simulate microwave snow radiances for different surface emissivity estimates/models, ice scattering assumptions (e.g., density, shape) and CRTM radiative transfer solvers using these hydrometeor profiles; develop error estimates for observations and radiative transfer models